Space Weather Technical Forecast

Issued on Saturday, 04 March 2023 at 13:16 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Slight chance of Strong R3 radio blackouts. Chance of Minor Geomagnetic Storm G1 intervals. Active Electron fluence increasingly likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High over the past 24 hours, with an X-class flare observed by GOES16 and peaking at X2.1 at 03/1752UTC,from sunspot region AR3234. This initiated a significant Coronal Mass Ejection (CME). AR3234 is currently rotating off the visible disk, having produced a further M-class flare in the past 24 hours. AR3242 in the northeast is now the largest area on the disk and has shown some development in the leader spot as well as further emergence of the intermediate and trailing spots. AR3243 in the northwest has also shown development in the last few hours and may be becoming increasingly active. Most of the remaining regions are unchanged unipolar and appear inactive. At present there are thought to be no significant Earth-directed CMEs, however this is discussed further below.

Solar Wind / Geomagnetic Activity: The solar wind as observed at L1 by DSCOVR and ACE, was likely connected to a negative polarity fast solar wind, with the phi angle accordingly negative (towards the Sun) throughout. The source of this activity is not certain, but may comprise a combination of fading CH79/- and the likely arrival of the HSS associated with the large and equatorial CH81/-. The solar wind speed has been mostly elevated and is currently assessed around 600km/s. The solar wind density was below average in low single-figures ppcc. The IMF was relatively smooth in character, reaching a peak of around 8.7nT at 03/1805UTC with weak to moderate levels observed. The north-south component varied between +/-8nT, with a predominantly anti-aligned bias with Earth's field. The net effect of the above solar wind measures was for Quiet to Active geomagnetic activity, with provisional Kp peaks of '4-'.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 remained at Background levels. Electron flux at GOES16 was initially at background becoming moderate to high and peaking at 1400pfu at 03/1600 UTC. Electron fluence has been below the Active threshold (1e8 integrated flux), with a flat trend observed and a value of 4.41e7 integrated pfu at 04/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Though AR3234 now rotating over the limb the flare risk remains elevated, particularly as new regions rotate into view. Moderate solar activity expected with further M-class flares likely and a slight but reducing chance of isolated X-class flares giving High solar activity.

Solar Wind / Geomagnetic Activity: No significant Earth-directed CMEs feature in the current forecast, however there is a low risk of a glancing blow from the fast CME associated with the X2.1 flare 03/1752 UTC, which could possibly arrive sometime during Day 3 (6th). The current geomagnetic forecast is dominated by the HSS related to CH81- which only looks to wane later into Day 3 (6th) or more likely Day 4 (7th). A chance of G1 Minor Geomagnetic Storms throughout, with the risk on Day 3 (6th) more associated with the possible arrival of the

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aforementioned CME glancing blow.

Energetic Particles / Solar Radiation: Although High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels, recent flare activity and the X2.1 flare observed implies there remains a slight chance of protons increasing in the immediate term, reverting to the raw risk for the disc at nearer 10% into the new working week. Electron flux is likely to be at moderate to high levels perhaps becoming suppressed given any more active geomagnetic activity. Electron fluence is currently forecast to remain below the active threshold through Day 1 (4th) but potentially rising above active levels into the period, though the potential for geomagnetic activity through Days 2 and 3 (5th and 6th) mean lower confidence.

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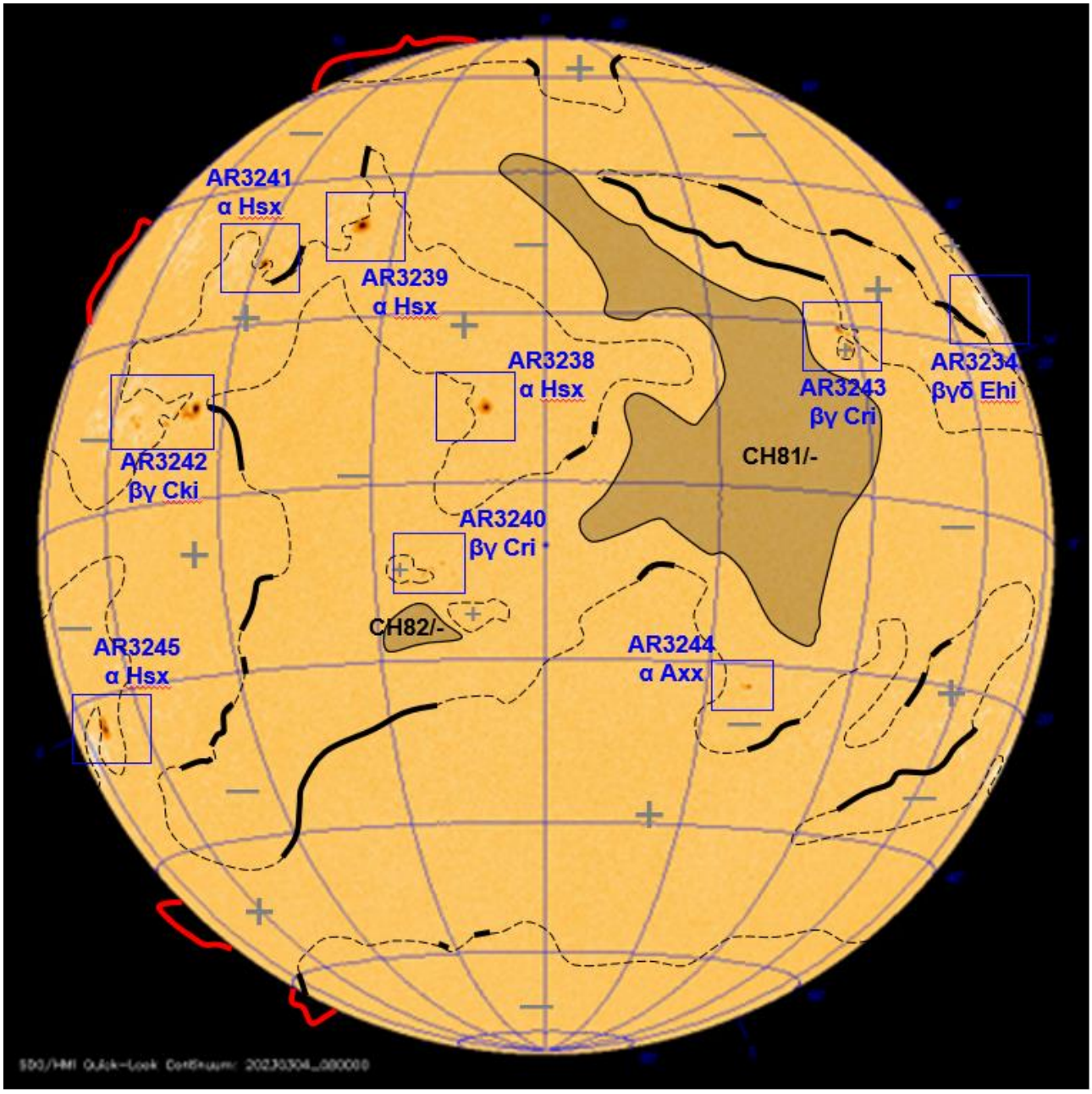
Figure 1. Solar Analysis Valid 04/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No significant Earth-directed CMEs feature in the current forecast. However there is a low risk of a glancing blow from the fast CME associated with the X2.1 flare 03/1752 UTC, which ensemble forecasts are signaling could possibly arrive sometime during Day 3 (6th).

The current geomagnetic forecast is dominated by the HSS related to CH81- which only looks to wane later into Day 3 (6th) or more likely Day 4 (7th). Earth is currently very close to the March equinox, and as such negative polarity features ought to be maximally potent. Earth does in fact reach its maximum southward limit with respect to the solar equator towards the end of this four-day forecast, before undergoing a gradual six-month journey back northwards. On last pass the analagous feature to CH81- gave a protracted spell of Active and then Unsettled Kp, with a relatively higher risk of reaching G1 expected on this pass, probably front-loaded to the main and most intense portion of the coronal hole which looks to peak overnight into Day 2 (5th) based on ENLIL output, but lower confidence resulting in a smooth partitioning of this risk between UTC days. Strong solar winds probably only slowly easing from Day 2 (5th) onwards. Overall a chance of G1 Minor Storms throughout, with the risk on Day 3 (6th) more associated with the possible arrival of the aforementioned CME glancing blow

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	45	40	40	30
Strong	G3	No	1	1	5	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
03/2258 UTC	Partial	AR3234	NW	802	06/0900 UTC	Glancing blow possible, but most material observed to west of solar disc.

Figure 2: Latest ENLIL Ensemble showing low risk of possible glancing CME effects into the 6th and signal for HSS.

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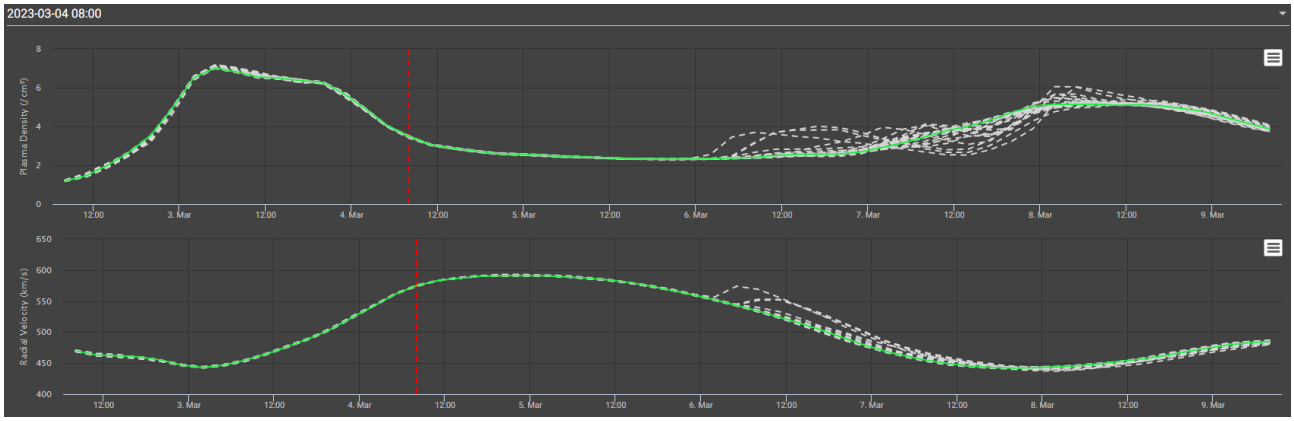

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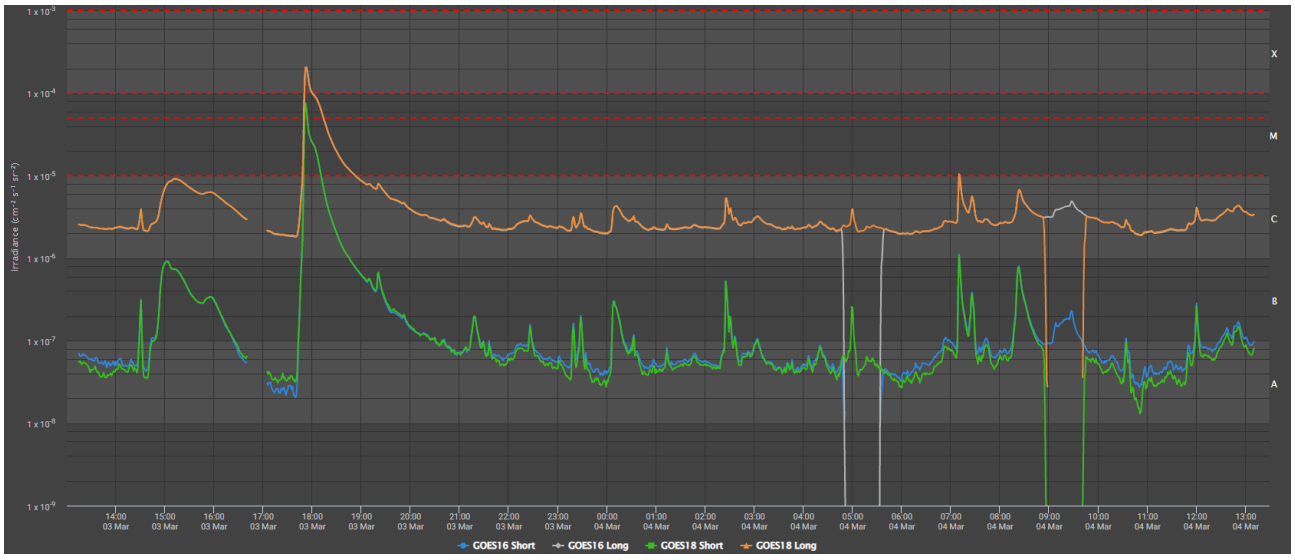
Radio Blackouts - X-Ray Flares:
AR3234 currently rotating off the visible disk, having produced the X-class flare (X2.1 at 03/1752UTC) as well as an M-class flare in the past 24 hours. It is no longer possible to definitively identify any changes to size or classification/ Delta spot(s), however it is suspected to persist as a complex and active area in light of recent flares and as such contributes to the flare risk well into Day 2 (5th). AR3242 in the northeast is now the largest area on the disk and has shown some development in the leader spot as well as further emergence of the intermediate and trailing spots. AR3243 in the northwest has also shown development in the last few hours and may be becoming increasingly active. Most of the remaining regions are unchanged unipolar and appear inactive. Far side data does suggest multiple sunspot regions massing behind the eastern limb with a steady stream looking to emerge onto the visible disk during the period. Their contribution to any risk increase into the coming new UTC week is not assured but for now helps to maintain risk values into Days 3 and 4 (6th/7th).

Though AR3234 now rotating over the limb the flare risk remains elevated, particularly as new regions rotate further into view. Moderate solar activity expected with further M-class flares likely with a slight but reducing chance of isolated X-class flares giving High solar activity.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	Yes	60	55	50	50
Very Active	**R3 to R5 X Class**	Yes	20	15	10	10

Figure 3: Latest 24hr X-ray plot.



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Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels.

Although S1 radiation storms have not been observed given recent flare activity the X2.1 flare observed implies there remains a slightly increased chance of protons increasing in the immediate term, reverting to the raw risk for the disc at nearer 10% into the new working week. Dominating this risk is AR3234, which will continue to present a gradually fading risk as the region rotates off behind the western limb into Day 2 (5th).

While yet to appear, the numerous arriving eastern hemisphere spots due in the period should not appreciably contribute to the risk of S1 or greater until later next week.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	15	10	10
Very Active	**≥ S3 ***	No	5	5	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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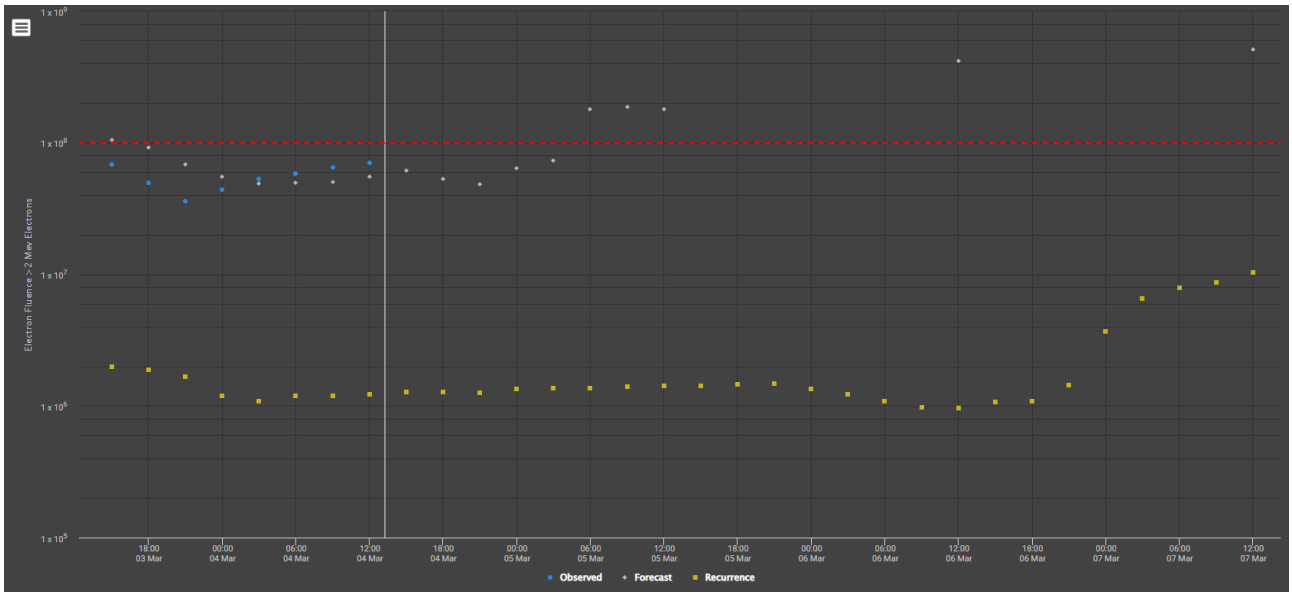
High Energy Electrons Event (≥ 2MeV):
Electron flux is likely to be at moderate to high levels perhaps becoming suppressed given any more active geomagnetic activity, however High levels are eventually expected given current HSS, with this most likely to occur into Day 4 (7th). Electron fluence is currently forecast to remain below the active threshold through Day 1 (4th) but potentially rising above active levels into the period.

MOSWOC REFM shows a suppressed forecast for the next 12 hours, before a general trend above active levels which is accepted though the potential for geomagnetic activity through Days 2 and 3 (5th and 6th) mean lower confidence

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	40	60	70	80
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	5

Figure 4: Latest MOSWOC REFM model output.



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